Productivity change in Nigerian seaports after reform: a Malmquist productivity index decomposition approach

Journal Item

Productivity change in Nigerian seaports after reform: a Malmquist productivity index decomposition approach

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Abstract

During the 1990s, Nigerian seaports were considered inefficient, unsafe due to massive cargo theft (wharf rat phenomenon) and one of the most expensive port systems in the world. This resulted in long turnaround times for ships and increased container dwell times. As a result, port operations were transferred to the private sector through concession contracts. This paper employs a Malmquist Productivity Index (MPI) technique to benchmark pre-and post-reform total factor productivity growth of the six major Nigeria seaports (Apapa, Calabar, Onne, Port Harcourt, TinCan Island and Warri) for the period 2000-2011 which represents six years before (2000-2005) and six years after (2006-2011) the reform. The results indicate progress in technical efficiency of the ports after reform but deterioration in technological progress. Overall productivity growth was higher in the pre-concession period compared to the post-concession period. The source of pre-concession period productivity growth was technological progress while the change in productivity of the post-concession period is generated by an increase in scale efficiency. This suggests that concessionaires have not brought in the much anticipated investment in modern technology to drive port efficiency. The ports of Calabar and Apapa experienced the highest productivity growth while lowest result was Onne.

Keywords: Ports, Nigeria, Productivity, Reform, Malmquist Productivity Index, Measurement

Introduction

Although the public sector has been organising ports globally, the present economic reality of increasing fiscal needs and reductions to public budgets has made the practice unsustainable. Therefore, the last two decades, there has been a growing emphasis towards port reform to create an efficient, competitive and productive port system globally. Consequently, countries have to seek private intervention in the port industry. Trujillo and Nombela (1999) have argued that private participation in both infrastructure and operation has improved the performance of seaports globally.

Ports in both developed and developing countries have reformed ports through varying degrees of private participation. Nigerian ports were not left out of the new order, as the country engaged in an unprecedented port reform in 2005 that culminated in the delineating of the six major ports into 20 terminals and the handing over of operations to the private sector in one scoop. As observed by Estache, González, and Trujillo (2001), a common feature of reforms is monitoring and evaluation. Hence, the need to assess the Nigerian ports' reform to ascertain whether the ports are on the path of achieving the objectives of the reform. This study assesses the performance of the ports after the reform by employing a productivity change analysis. The study is motivated by the lack of empirical studies on port reform outcomes in Africa and Nigerian in particular despite the Nigerian port reform being dubbed the most ambitious port reform that has taken place globally (Ocean Shipping consultants 2008).

The aim of this paper is to contribute to the stock of literature on the effect of port reform on the performance by analysing productivity change in Nigerian seaports after a major policy reform.

The rest of the paper is structured as follows: section 2 contains a brief description of the Nigerian port reform process. Section 3 reviews literature related to port productivity, section 4 introduces the Total Factor Productivity (TFP) methodology using Malmquist Productivity Index (MPI) approach. Sections 4 and 5 discusses the results and conclusion respectively.

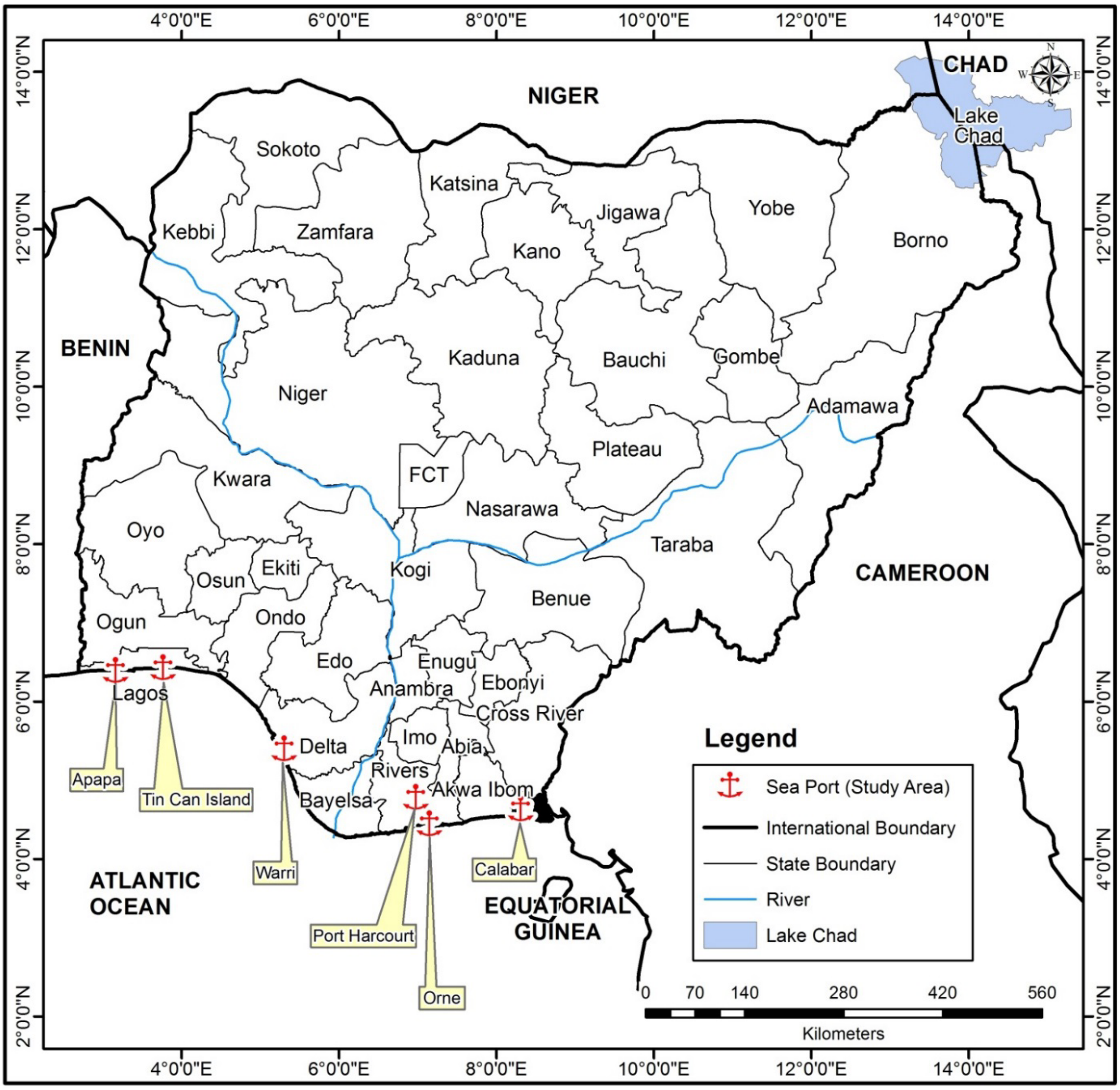

Figure 1: Map of Nigeria showing Major Sea Ports (Study Area)
Source: Modified from the Administrative Map of Nigeria

The Nigerian port sector and the port reform process

Nigeria had eight seaports that constituted the primary port system prior to reform. The eight major ports were merged into six (Apapa, Calabar, Onne, Port Harcourt, Tincan island and Warri) after the reform, all under the control of the Nigerian Ports Authority (NPA). The ports were non-autonomous, and administration was highly centralised. The ports practised the tool port system of port administration before the reform with the exception of Onne port, which adopted the landlord system throughout the observed period. Prior to reform, the Nigerian port sector was characterised by poor performance compared to other West African ports. The port system was characterised by an over-bloated workforce, corrupt practices, insecurity of cargo, underinvestment, obsolete infrastructure, limited integration with inland transport and excessive charges (Mohiuddin 2006). In addition, there were serious ship delays, cumbersome and bureaucratic clearing procedures and limited storage space. In order to decongest the ports, ships bound for Lagos ports were diverted to the Eastern ports of Port Harcourt, Calabar and Warri and even to other neighbouring West African Countries ports. To address the infrastructural gap and the myriad of problems confronting the port sector. The Federal Government of Nigeria (FGN) embarked on the concession of the six major ports between 2004 and 2006 which culminated in the transfer of terminal operations from the public to the private sector through concession contracts and the adoption of landlord model of port administration.

There are studies such as Estache, González, and Trujillo (2002), that have investigated the productivity of Mexican ports after reform, Barros, Assaf, and Ibiwoye (2010), Barros (2012) and Barros and Peypoch (2012) that investigated the productivity of African seaports using ports from Angola, Mozambique and Nigeria but no study has looked at the influence of Nigerian ports reform on the productivity of the ports. The Nigeria port privatisation is a guinea-pig for studying the impact of wholesale concessions on the performance of national ports in Africa and indeed the whole World, due to the manner and speed in which the programme was executed. In the African context, it is the only country that has embraced the advanced form of landlord model of port administration in Sub-Saharan Africa. According to Ocean Shipping consultants (2008), the Nigerian port concession accounted for 55% of the private investment in ports in the sub-region, totalling $1.3billion as at 2008. Therefore, the need to evaluate such an elaborate concession on the productivity of the ports cannot be overemphasised.

Literature on productivity change in the port industry

The study adopts the concept of Total factor productivity (TFP) which can be simply defined as the rate of change of total output in relation to total input. The concept of TFP is used to measure or decompose changes in productivity over time or between firms by aggregating multiple inputs (M) and outputs (S). The concept can metamorphose into Multi-Factor Productivity (MFP) when used to relate a single output to a collection of inputs. Fung et al. (2008) identified three major indices that have been used in productivity studies as Törnqvist index developed by Törnqvist (1936), the Fisher index by Fisher (1922) and Malmquist index derived from the ideas of Malmquist (1953) and has been the most extensively applied index in productivity studies.

Gonzalez and Trujillo (2005), identified three drawbacks of Törnqvist and Fisher indices as follows: measurement requires quantitative data and market prices which are neither available in most cases nor well suited for weight aggregation. As most port research, especially those involving ports globally are bogged down by inadequacy of data for effective comparison. As a result, Törnqvist and Fisher indices are not common with port productivity studies. Also, price may not be meaningful economically in the estimation of productivity of non-market activities such as port operations in certain countries and under some institutional arrangements and management systems. On the other hand, the basis of Malmquist index is not profit maximisation or cost minimisation and neither does it require information on input and output prices. Secondly, it allows for the decomposition of productivity change into technical efficiency change, or catch-up effect and technological change, or frontier shift effect components. The technical efficiency change measures the ability to make the use of available technology while technological change refers to the improvement or deterioration in the state of technology (Coto-Millán, Pesquera, and Castanedo 2010).

There are studies that employed MPI to measure efficiency change in the port industry such as Liu, Liu, and Cheng (2006) estimated the productivity of major container terminals in Mainland China from 2003-2004 using MPI. The study discovered that the most efficient are the large ports and in terms of ownership that Sino-foreign joint ventures performed better than domestic companies. De (2006) investigated the total productivity growth of Indian ports from 1981-2003 using MPI. The study revealed that there is no substantial impact on TFP of Indian ports after reform.

In assessing the productivity change after Mexico's port reform, Estache, De La Fe, and Trujillo (2004) found short-term improvement in technical efficiency after the reform. Likewise, De Langen and Pallis (2007) study of the total productivity of principal container terminals in Mexico showed improvement in all the ports. Barros, Felício, and Fernandes (2012), applied Malmquist index with the technology bias to analyse the productivity of Brazilian ports. The result of the analysis suggests that Brazilian ports on average became less productive with improvements in efficiency and deterioration in technological change. Díaz-Hernández, Martínez-Budría, and Jara-Díaz (2008) used MPI to measure the productivity of cargo handling in Spanish ports and attributed sources of productivity change to technical change rather than efficiency change. In the same vein, Haralambides et al. (2010) employed

Malmquist index and a Luenberger indicator (a productivity indicator that can contract inputs and expand outputs simultaneously) to assess the productivity of 16 Middle East and East Africa seaports. The result indicated that ports in the region declined in technical efficiency in spite of positive developments in the adoption of new technology. Also, Fung et al. (2008) used DEA-based Malmquist index approach in the measurement of productivity of Chinese container terminals from 2006-2011 and found improvement in productivity and the source of the growth to be technological progress. Cheon, Dowall, and Song (2010) assessed the productivity of 98 World ports in 1991 and 2004 and found that the change in ownership improved productivity of the container terminals especially for the large ports. Yuen, Zhang, and Cheung (2013) analysed 21 container terminals in China, South Korea and Singapore from 2003-2007 using MPI approach and concluded that foreign participation in the terminals have a positive impact on their productive efficiency.

Methodology

Caves, Christensen, and Diewert (1982) have demonstrated that productivity change can be measured relative to two-time periods t, and t+1. A productivity index developed based on distance functions is called Malmquist index. Färe et al. (1994) applied it to decompose productivity growth into two mutually exclusive components: technical change and technical efficiency change overtime, which measures frontier shift and catch-up effect, respectively. However, if MPI is expressed based on DEA efficiency measures it is defined as the ratio of the efficiency measures for the same production unit in two different time periods or between two different observations for the same period (Odeck 2000, Rezitis 2008).

Hence, measurement of port efficiency changes and identification of sources of technical change is achieved by employing the concept of DEA based Malmquist Total Factor Productivity Index or Malmquist Productivity Index (MPI). MPI can be calculated from standard DEA scores to benchmark port efficiency between two-time periods. The basic idea is that if efficiency change has occurred over a long period, temporal changes in efficiency can be attributed to two different sources related to port conditions, planning and management. These are: (a) frontier shift effects and (b) catch-up effects (Cheon 2007a, Estache, González, and Trujillo 2002, Estache, De La Fe, and Trujillo 2004). The frontier shift effects involve shift in the productive efficiency frontier and occur as a result of significant changes in technological progress. Port efficiency gains from the frontier shift effects is attributable to the ability to keep up with the latest technologies which may be driven by institutional reforms such as concession to increase (or decrease) market competition. To continuously keep in touch with the latest technology (such as deploying modern cargo handling equipment and ICT for cargo tracing) requires effective long-term strategic planning and timely capital investment at the port and policy making level.

Conversely, the catch-up effect also known as technical efficiency change is represented by a port movement along the production frontiers, which can occur even within a short period. The catch-up effect is so named because the concept implies the capacity of ports to follow best practices in order to operate on the frontiers at any point in time. The efficiency gains emanating from the catch-up effect can be mainly attributed to managerial capacity of ports to (a) respond to port demand by flexibly adjusting production scales (changes in scale efficiency) and to (b) adjust input factors timely (changes in "pure" technical efficiency). Not only incentive changing policies but also many other management systems and conditions could promote this type of behavioural change.

The time periods under measurement for this research, are the pre- and post-concession port efficiency of Nigerian ports over a 12-year period (2000-2011). The Nigerian ports during this period under review have undertaken a major port reform programme described by Africa Infrastructural Diagnostic Study 2008, as the most ambitious and far reaching port reform to be undertaken in Africa or the World. Therefore, in order to determine the influence of port concessions on port performance, it is meaningful to use MPI approach that decomposes into different sources of efficiency growth and technological progress. The decomposition can be useful in understanding factors responsible for productivity growth for policy implementation purposes. Thus, the MPI model is adopted to separate temporal changes in productive efficiency into (a) technological progress and (b) change in technical (managerial efficiency).

The above differentiation has policy implications because it identifies the different sources of inefficiency. For example, if a port does not efficiently utilise its existing assets and input factors, but tries to attribute its inefficiency to its level of technology and lack of long term investment, the result of these courses of action would be creations of ineffective and unreasonable policies (Cheon 2007b). Therefore, productivity change analysis identifies not only if productivity has deteriorated or progressed but underpins the sources of inefficiency.

The MPI measures the total productivity change between two-time periods (pre-and post-concession) Cheon, Dowall, and Song (2009). It calculates the ratio of distances of each data in each period relative to a common technology. If the technology in period t1 is regarded as the reference technology and the base year for the comparison is period t0, the Malmquist total factor productivity change index between t0 and t1 can be presented thus:

$$\frac{TFP_{t1}}{TFP_{t0}} = \frac{d_{t1}\,(x_{t0}, y_{t0})}{d_{t1}\,(x_{t1}, y_{t1})} \qquad \textbf{(1)}$$

Where, $d_{t1}(x_{\propto}\,, y_{\propto})$ represents the distance from the observation in period t0 to the period t1 technology, a value of the above index greater than one indicates a percentage improvement in total factor productivity during the two periods, t0 and t1.

Fare, Grosskopf, and Lovell (1994) redefined this index suggesting an alternative practice to avoid having to choose between technologies in period's t0 and t1. The alternative concept is based on the geometric mean of two indices that are comprised by two of one period in comparison to the other. The first is evaluated with respect to the period t1 technology and the second with respect to period t0 technology.

$$\frac{TFP_{t1}}{TFP_{t0}} = \left[\frac{d_{t1}\,(x_{t0}, y_{t0}) d_{t0}\,(x_{t0}, y_{t0})}{d_{t1}\,(x_{t1}, y_{t1}) d_{t0}\,(x_{t1}, y_{t1})}\right]^{\frac{1}{2}}$$

$$= \frac{d_{t0}\,(x_{t0}, y_{t0})}{d_{t1}\,(x_{t1}, y_{t1})} \left[\frac{d_{t1}\,(x_{t1}, y_{t1})\; d_{t1}\,(x_{o}^{t}, y_{0}^{t})}{d_{t0}\,(x_{t1}, y_{t1})\; d_{t0}\,(x_{t0}\,, y_{t0})}\right]^{\frac{1}{2}} \qquad \textbf{(2)}$$

Equation (2) can be rewritten as the output-oriented scores (φ), since the efficiency scores are the ratios of distance in the production frontiers:

$$\frac{\varphi_{t0}\,(x_{t0}, y_{t0})}{\varphi_{t1}\,(x_{t1}, y_{t1})} \left[\frac{\varphi_{t1}\,(x_{t1}, y_{t1})\; \varphi_{t1}\,(x_{0}^{t}\,, y_{0}^{t})}{\varphi\,(x_{t1}\,, y_{t1})\; \varphi_{t0}(x_{t0}, y_{t0})}\right]^{\frac{1}{2}} \qquad \textbf{(3)}$$

$$\mathrm{A} \qquad \times \qquad [B]$$

The part "A" in equation (3) represents change in technical efficiency (catch-up effect) between period's t0 and t1, while "B" measures technological change (frontier shift effects) during the same period. It has been argued that in order to properly measure total factor productivity using this concept, Constant Returns to Scale (CRS) distance functions are required. A change in technical efficiency, representing catch-up effect, consists of changes in scale and non-scale factors denoted as "pure" technical efficiency change. As the DEA under Variable Returns to Scale (VRS) does not measure the impact of production scale on efficiency, the MPI with Variable Returns to Scale (VRS) distance functions cannot measure change in scale efficiency (Fare, Grosskopf, and Lovell 1994). It thus leads to the miss-specification of the size of frontier shift effects.

By introducing the VRS model, equation (2) and (3) becomes a more refined index in equation (4) (Zhu 2003, Cooper, Seiford, and Zhu 2011, Färe et al. 1994).

$$\frac{d_{t0}^{v}\,(x_{t0}\,,y_{t0})}{d_{t1}^{v}\,(x_{t1},y_{t1})}\left[\frac{d_{t1}^{v}\,(x_{t1},y_{t1})d_{t0}^{c}(x_{t0},y_{t0})}{d_{0}^{v}\,(x_{0},y_{0})\,d_{t1}^{c}\,(x_{t1},y_{t1})}\right]\left[\frac{d_{t1}^{c}\,(x_{t0},y_{t0})\,d_{t1}^{v}\,(x_{t1},y_{t1})}{d_{t0}^{c}\,(x_{t0}\,,y_{t0})\,d_{0}^{v}\,(x_{1}\,,y_{1})}\right]^{\frac{1}{2}}$$

$$= \underbrace{\frac{\varphi_{t0}^{v}\,(x_{t0},y_{t0})}{\varphi_{t1}^{v}\,(x_{t1},y_{t1})}}_{A'}\underbrace{\left[\frac{\varphi_{t1}^{v}\,(x_{t1},y_{t1})}{\varphi_{0}^{v}\,(x_{0},y_{0})}\;\frac{\varphi_{t0}^{c}\,(x_{t0},y_{t0})}{\varphi_{0}^{v}\,(x_{0},y_{0})}\right]}_{A''}\underbrace{\left[\frac{\varphi_{t1}^{c}\,(x_{t0},y_{t0})}{\varphi_{t0}^{c}\,(x_{t0},y_{t0})}\;\frac{\varphi_{t1}^{v}\,(x_{t1},y_{t1})}{\varphi_{0}^{v}\,(x_{1},y_{1})}\right]^{\frac{1}{2}}}_{B} \quad \textbf{(4)}$$

Where, φ^{v} are output-oriented efficiency scores under VRS and φ^{c} is output-oriented efficiency scores under CRS.

In equation (4), the changes in technical efficiency, A in equation (1), is separated into change in "pure" technical efficiency (A') and the change in scale efficiency (A") and B still remains technological progress. The product between "pure" technical efficiency (A') and scale efficiency (A") is called Total Technical Efficiency Change (TTEC) representing catch-up effects (Cheon, Dowall, and Song 2009). This separation is interesting because changes in scale efficiency of ports are often determined by changes in external demand driven by economic size and strengths of port hinterlands which is outside the control of port authorities. By separating the sources of inefficiency changes, it is possible to carefully examine the influence of different factors on port productivity.

Data

The unit of analysis in this paper are six major Nigerian ports operations for the periods (2000-2005) and (2006-2011) representing the pre-and post-concession periods respectively. The variables used in the analysis were selected carefully, because, as the number of variables increases the discriminatory capability of DEA diminishes. There is no theory on the choice of variables although Raab and Lichty (2002) suggested a general rule of thumb that the minimum number of DMUs should be greater than three times the combined number of inputs and outputs. Therefore, four input variables were selected; number of berths, port storage capacity in tonnes, the total number of equipment and the total number of staff as a proxy for Stevedore labour.

The output variables selected are annual total cargo throughput in tonnes and ship turnaround time. Previous studies from the literature have treated throughput as an output variable because it is the basis of comparison of ports in relation to the size, investment magnitude or activity levels. Turnaround time is used as the second output variable in this study as one of the main objectives of Nigeria's seaport concessions is to reduce the time ships stay at ports in order to attract more ships to Nigeria's ports.

Results Analysis

The MPI technique is employed first to measure the efficiency change on year-by-year basis to benchmark the total efficiency of Nigerian seaports terminal operations between any two successive years in order to track down short-term changes in efficiency. Secondly, the analysis is split by concession-period to estimate productivity change between pre-and post-concession period operations.

A summary of the results obtained for the year-by-year MPI and decomposition using non-parametric DEA distance functions is presented in appendix 1. It shows that 34 port-years achieved productivity gains while 16 port-years recorded productivity loss. Another 16 port-years showed no change in total productivity for the period under review.

Figure 1 shows the variations in the average productivity of the combined MPI result from all the years. It depicts that efficiency changes of MPI and its decomposition fluctuates without a definite pattern. For instance, the pure technical efficiency (PECH) started with significant fluctuations and almost flattened out from 2004-2005 to the end of the observation period. On the other hand the total factor productivity change (TFPCH) and scale efficiency change (SECH) depicted identical pattern of troughs and peaks with the highest peak of TFPCH occurring in 2005-2006 which is the swing year while SECH is highest during the 2008-2009 period. This is different from the observations from studies using ports from developed countries; most ports in developed countries witnessed deterioration in throughput levels for the period 2008-2009 due to the economic meltdown. However, the ripple effect was not felt in developing countries until 2010-2011. However, technical change (TECHCH) compared to other decompositions exhibited a gradual decline up to 2003-2004, then a deterioration in 2003-2004. Then the growth in 2004-2005 and a sharp increase in 2005-2006, the swing year. It is followed by a sharp deterioration in 2006-2007, which persisted till the end of the study period.

Figure 1 shows overall a general trend of fluctuations in total factor productivity in all the indices although there were more years with positive changes in efficiency (EFFCH) than decrease while TECHCH have more years with deterioration. There is an appreciable increase in overall efficiencies in 2005-2006 which is the swing year (transfer of terminal operations from public to a private sector through concession contracts) followed by a noticeable decline. This may be attributable to concessionaires (terminal operators) trying to familiarise themselves with the new business environment and to build a customer base.

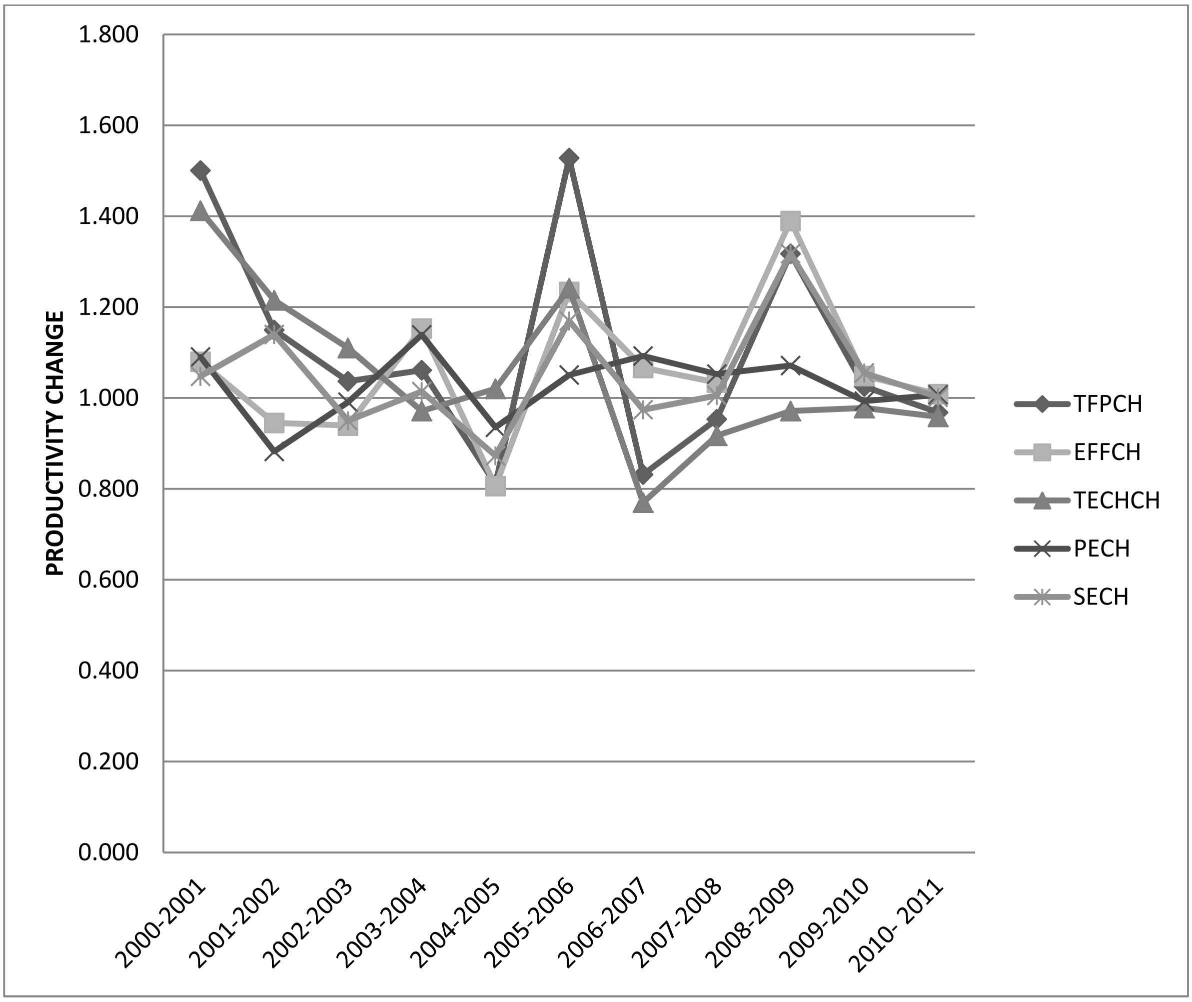

Figure 2: Trend of Year-by-year averages of MPI and components

Table 1: Malmquist productivity index summary of port means (2000-2011)

PORT	EFFCH	TECHCH	PECH	SECH	MTFPCH
APAPA	1.044	1.088	1	1.044	1.150
CALABAR	1.172	0.990	1	1.172	1.154
ONNE	1	1.012	1	1	1.012
PH	1	1.114	1	1	1.114
TCIP	1.052	1.049	1.018	1.029	1.087
WARRI	1.117	1.055	1.149	1.054	1.128
MEAN	1.064	1.0514	1.028	1.050	1.107

Table 1 shows that in average all the ports experienced productivity growth during the period, and the average TFP growth for the period under review is 10.7% (mean MTFPCH = 1.107). The overall positive TFP growth of the ports is attributable to frontier based capabilities. The technical efficiency change (EFFCH) is more than one (mean EFFCH 1.064) signifying a positive growth of 6.4%. The result indicates that both PECH and SECH values are greater than unity that shows a positive increase of 2.8% and 5% respectively. It implies that both have contributed in technical efficiency change with SECH having an overriding impact.

The overall mean technical change (TECHCH) of the ports showed a positive increase of 5.14% (Table 1). It shows that overall the total factor productivity growth observed for the study period is more due to improvement in efficiency than technical change (TECHCH) as the value of efficiency change is higher than technical change. The decomposition of the efficiency change (EFFCH) into pure technical and scale efficiency change reveals that Apapa, Calabar, Onne and PH have stability in pure technical efficiency change (PECH=1) while Onne and PH ports also have stability in scale efficiency change (SECH=1). The ports that have stagnation in efficiency for the period are faced with the problem of using excessive inputs (especially storage capacity) in producing outputs (throughputs), so the ports are confronted with inefficiencies arising from producing under decreasing returns to scale.

The correlation between multi-year MPI and sources of efficiency shows that productivity gain achieved from pure technical efficiency has a significant influence on the improvement of overall efficiency of Nigeria ports as indicated by the mean of the year-by-year correlation (0.598) in appendix 2. The substantial impact of non-scale pure technical efficiency implies that terminal operators were more interested in improving the capability of productive units (terminals) to increase production with the set of given inputs and available technology. The negative relationship between MPI and scale efficiency change observed in 2005-2006 highlights the presence of overcapacity accounting for uneconomical scale sizes.

Overall, scale efficiency change (SECH) has a statistically reasonable influence on total factor productivity though not as much as pure technical change.

The overall average of the year-by-year correlation between MPI and technical change (TECHCH) is 0.286 which shows that the shift in frontier technology has no statistically meaningful impact on total factor productivity. Again the impact of frontier technology on TFP is less than the scale and non-scale components. The trend of the relationship shows that the swing year 2005-2006 is marked with the lowest impact of scale efficiency change on TFP, and then a sharp rise in 2006-2007. Thereafter, a gradual decline in 2007-2008 and a sharp decline in 2008-2009, which is a period of declining trade volume globally induced by the banking crisis and suspension of ship entry into the ports of Lagos due to congestion.

The transfer of terminal operations of Nigeria's seaports to the private sector through concessions has been in operation for six years. The results obtained from the technical change component of MPI may give an idea of the influence of concession on the operational efficiency of Nigerian ports. The result of the MPI decomposition indicates that PECH has the lowest variance compared to the other components followed by TECHCH. Considering that pure technical efficiency implies that the ports can produce more using existing technology and utilizing available inputs efficiently, the very highly significant relationship between MPI and PECH coupled with low variance means that organisational and managerial factors associated with better balance between inputs and outputs are necessary for port productivity. Also, the small, but moderate relationship between MPI and technological change (TECHCH) together with low variance suggests that frontier shift effect does not yield substantial gains in TFP at least in the short run. As technological change is driven by the ability of ports to invest in modern cargo handling equipment, advanced ICT systems and also cargo tracking and scanning equipment. The relationship between technological change and MPI further suggests the unwillingness of terminal operators to bring in new technologies as specified in the concession agreements. It underscores the need for an independent regulator to ensure compliance of the concession agreements. The analysis also reveals a negative association between scale efficiency and TFPCH in 2005-2006, suggesting that small ports could not produce a unit of port service at inputs comparable to those of large ports.

Analysis of pre-and post-concession productivity change

The analysis of year-by-year MPI although useful in evaluating the short-term efficiency changes in productivity does not provide an insight on the influence of concession on productivity. The effect of transfer of operations from public to private could only be noticed in the medium to long term periods. To explore the influence of concessions performance the study measured TFPCH for the pre-and post-concession period. It is necessary for tracking the overall effect of the different factors on TFP.

Table 2: Descriptive statistics of pre- & post-concession TFP and its decompositions

		MPI	EFFCH	TECHCH	PECH	SECH
PERIOD	N	30	30	30	30	30
2000-2005	MEAN	1.112	0.985	1.146	1.007	1.015
	MEDIAN	1.119	0.985	1.143	1	1
	STDEV	0.079	0.051	0.042	0.081	0.039
	MIN	0.975	0.909	1.087	0.896	0.966
	MAX	1.204	1.062	1.204	1.149	1.074
2006-2011	MEAN	1.019	1.109	0.919	1.043	1.061
	MEDIAN	1.021	1.077	0.909	1	1
	STDEV	0.111	0.138	0.077	0.067	0.140
	MIN	0.863	1	0.821	1	0.996
	MAX	1.146	1.3448	1.009	1.13538	1.345

The result of the MPI analysis and the decomposition is presented in table 2. The mean value of the index for the two periods indicates a positive productivity change, but while TFP percentage growth in the pre-concession period is 11.2% (MPI=1.112) it is only 1.9% (MPI=1.019) for the post-concession period for the same number of years. For the technological change, it increased by 14.6% during the pre-concession period and deteriorated by 8.1% during the post-concession period. The pure technical efficiency showed an increase of 4.3% during the post-concession period and recorded a slight increase of 0.7% during pre-concession. The scale efficiency shows a slight increase for the two periods. The increase is 1.5% (mean MPI=1.015) and 6.1% (mean MPI=1.061) for the pre- and post-concession respectively (Table 2).

The analysis further reveals that the pre-concession productivity is driven by technological progress while it is an increase in technical efficiency for the post-concession. A decomposition of the EFFCH shows that for both the pre-and post-concession period the increased productivity is attributable to scale rather than technical efficiency as the values of pure technical efficiency change is less than scale efficiency change. The result also indicates that influence of shift in frontier technology on total factor productivity is overwhelming during the pre-concession era and barely significant after port operations are transferred to private operators. It suggests that the terminal operators have not brought the needed investment in ICT, tracking and technologies including modern cargo handling equipment that will fast track port development in Nigeria port sector and reduce turnaround time.

Table 3: Correlation between pre- & post-concession MPI and sources of efficiency change

	MPI DECOMPOSITIONS			
PERIOD	MPI/EFFCH	MPI/TECHCH	MPI/PECH	MPI/SECH
PRE-CONCESSION (2000-2005)	0.781	0.948	0.599	0.056
POST-CONCESSION (2006-2011)	0.794	0.145	0.504	0.545

The correlation between pre-and post-concession MPI and the decompositions gives an indication of productivity change after the transfer of port operations to the private sector. The relationship shows that TFP change during the pre-concession period is driven by frontier shift effects rather than catch-up effect, but the reverse is the case for post-concession period. The weak but moderate relationship between MPI and technical change indicates non-investment in technology by the terminal operators after the reform. In addition, the very weak relationship between total productivity change and scale efficiency change during the pre-concession period signifies under-utilisation of available resources as the ports could not attract the needed cargo. In other words, the level of inputs available to the ports far outweighs the throughput handled.

The reform of Nigerian ports through concession contracts improved the productivity of Nigerian ports through increased throughput levels (measure of scale efficiency) and slightly reduced the influence of pure technical efficiency change (table 3). On the other hand, the transfer of port operations to the private sector decreased the influence of technological change (frontier shift effects) of the ports. It is at variance with the objective of Nigerian ports concession which is to attract investment in port infrastructure from the private sector.

The pre-concession period in comparison to the multi-year MPI suggests that the influence of technological progress on productivity is not quite evident in the short-run. As a result of the changes in global trade due to introduction of bigger container ships and in preparation for the adoption of the landlord model of port administration, Nigerian port invested in ports infrastructure to attract reputable terminal operators to Nigerian ports. This, coupled with the insecurity experienced by the ports in the eastern zone, endemic cargo pilferage (Wharf rat phenomenon) and high cost of doing business in Nigeria ports made cargo diversion to other neighbouring countries ports prevalent. Hence the investment in port infrastructure was not matched with commensurate ship traffic and throughput levels, which led to under-utilization of port facilities in some of the ports and the resultant effect is observed in the relationship between MPI and SECH in the six years before concession which indicates that scale efficiency change has almost an insignificant impact on the productivity growth for the period.

In the same vein, comparing the relationship between multi-year MPI and its components with the relationship between MPI and its decompositions in the first six years of the post-concession period 2006-2011 the result indicates that the relationship between MPI and SECH is the most significant in comparison to technological progress (TECHCH) and pure technical efficiency change in the long run. This suggests that the impact of technological progress on productivity can be noticed in the medium term but in the long run the effect can only be felt through an increase in scale of production. It can be explained by observing the relationship between pure technical efficiency change and MPI, which is equally significant for the period. This implies that the terminal operators are using more advanced managerial skills to optimally utilise the available resources to improve throughput without investing in modern equipment. If this scenario continues unregulated, the resultant effect could be a higher turnaround time of vessels and loss of patronage.

Conclusion

The result shows a fluctuating trend in the productivity of all the ports. For the period under study, the port with the highest productivity growth is Calabar, followed by Apapa port while the lowest is Onne port. Although overall there is productivity growth during the two periods across all the ports. However, the pre-concession period recorded a higher increase in productivity than the post-concession period. A decomposition of the total factor productivity change suggests that pre-concession growth is due to technical change (frontier shift effect) while it is scale efficiency change (catch-up effect) for the post-concession period. The empirical result implies that resources in terms of modern equipment required to drive efficiency is not yet in place six years after the reform was implemented. The lower pure technical efficiency change compared to scale efficiency change after concessions suggests that the inefficiency is due to the inability of ports to meet target outputs (throughput and turnaround time). Therefore, policymakers should hasten the passage of the relevant laws to restore confidence in the terminal operators with concessions. The government should put in place a robust regulatory framework to ensure that concessionaires bring the required equipment as enshrined the respective concession agreements to improve the performance of the ports.

Another implication of the finding that the post-concession Nigerian port productivity is dependent on scale of operation to policymakers is that it may not be wise to invest public funds in acquiring facilities at small ports without clear commitment from carriers and shippers to utilise the facility and encourage expansion. The study suggests that failure to obtain such commitments will likely lead to under utilisation of resources and decrease in productivity.

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Appendix

Appendix 1: Descriptive statistics of Malmquist productivity index and decompositions

			INDEX DECOMPOSITIONS			
		MPI	EFFCH	TECHCH	PECH	SEC
PERIOD	N	66	66	66	66	66
2000-2001	MEAN	1.501	1.080	1.412	1.090	1.048
	STDEV	0.332	0.316	0.180	0.340	0.371
	MIN	1.098	0.809	1.200	0.780	0.551
	MAX	2.048	1.707	1.631	1.762	1.707
2001-2002	MEAN	1.149	0.945	1.215	0.882	1.140
	STDEV	0.217	0.070	0.201	0.218	0.339
	MIN	0.902	0.838	1.005	0.459	0.926
	MAX	1.524	1.010	1.524	1	1.826
2002-2003	MEAN	1.037	0.939	1.110	0.991	0.95
	STDEV	0.172	0.158	0.103	0.096	0.141
	MIN	0.831	0.664	0.955	0.822	0.664
	MAX	1.312	1.100	1.250	1.123	1.032
2003-2004	MEAN	1.061	1.153	0.971	1.139	1.014
	STDEV	0.201	0.392	0.256	0.395	0.063
	MIN	0.772	0.869	0.602	0.892	0.975
	MAX	1.337	1.934	1.337	1.941	1.140
2004-2005	MEAN	0.81	0.806	1.020	0.935	0.873
	STDEV	0.270	0.297	0.067	0.240	0.234
	MIN	0.447	0.416	0.898	0.461	0.416
	MAX	1.043	1.120	1.082	1.151	1.015
2005-2006	MEAN	1.528	1.234	1.241	1.051	1.170
	STDEV	0.361	0.242	0.199	0.106	0.234
	MIN	1.024	1	1.024	1	0.932
	MAX	2.131	1.651	1.580	1.265	1.651
2006-2007	MEAN	0.832	1.066	0.770	1.092	0.974
	STDEV	0.268	0.234	0.118	0.213	0.271
	MIN	0.641	0.875	0.649	1	0.851
	MAX	1.316	1.534	0.961	1.526	1.005
2007-2008	MEAN	0.953	1.034	0.917	1.053	1.006
	STDEV	0.253	0.239	0.131	0.082	0.061

	MIN	0.536	0.734	0.731	1	0.734
	MAX	1.284	1.471	1.098	1.167	1.430
2008-2009	MEAN	1.317	1.390	0.971	1.071	1.317
	STDEV	0.491	0.639	0.083	0.175	0.233
	MIN	0.961	1	0.861	1	1
	MAX	2.272	2.639	1.097	1.429	2.639
2009-2010	MEAN	1.025	1.049	0.978	0.993	1.055
	STDEV	0.157	0.156	0.034	0.016	0.655
	MIN	0.922	0.929	0.922	0.960	0.968
	MAX	1.338	1.362	1.019	1	1.362
2010-2011	MEAN	0.968	1.009	0.959	1.007	1.002
	STDEV	0.168	0.021	0.155	0.017	0.004
	MIN	0.712	1	0.712	1	1
	MAX	1.176	1.052	1.117	1.042	1.010

MPI=Malmquist productivity index representing Total Factor productivity change (TFPCH), EFFCH=Efficiency change, TECHCH=Technical change, PECH=Pure technical efficiency change, SECH=Scale efficiency change, N=sample size

Appendix 2: Correlation between Multi-year MPI and sources of efficiency change

	MPI DECOMPOSITIONS		
YEAR	MPI-PECH	MPI-SECH	MPI-TECHCH
2000-2001	0.545	0.269	-0.051
2001-2002	-0.011	0.166	0.909
2002-2003	0.514	0.653	0.080
2003-2004	0.306	0.277	0.427
2004-2005	0.630	0.597	-0.623
2005-2006	0.773	-0.037	0.512
2006-2007	0.405	0.875	0.737
2007-2008	0.825	0.633	0.627
2008-2009	0.967	0.004	-0.656
2009-2010	0.981	0.275	0.194
2010- 2011	0.604	0.604	0.993
MEAN	0.594	0.392	0.286